Bio-inspired Cellular Material Optimization for the Design of Additively Manufactured Multi-Functional Lightweight Structures, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

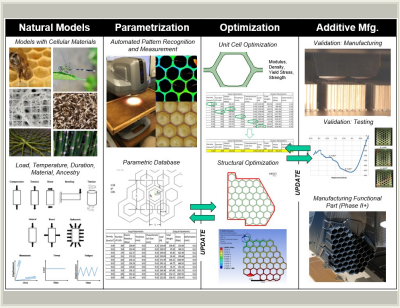
New technologies in imaging and manufacturing, including Additive Manufacturing (AM), are opening possibilities for mimicking biological structures in a way that has been unprecedented in human history. The primary innovation proposed here is the development of a tool that generates bio-inspired, parametrically optimized cellular materials for integration into the design of Additively Manufactured three-dimensional structures, and will have four main constituent parts:

1. Natural Models: Here we will identify biological models comprised of cellular patterns that will be used to parameterize the bio-inspired optimization tool.
2. Parametrization: Using our identified natural models, we will measure and evaluate design parameters that will be used as inputs in the optimization tool. These parameters will fall into two categories: environmental (loading condition and thermal requirements) and design (thickness, curvature, length, and known material properties).
3. Optimization Tool: At the heart of the proposal is an optimization tool that will use the commercially available Finite Element Analysis (FEA) software as its solver engine. The tool will operate on the environmental and design parameters (including material properties) developed in the previous part to identify clear structure-function relationships in the context of multiple objectives such as light-weighting and minimizing deformation. The output of the tool will both be reconciled against the data from natural models as well as used to design test specimens for validation with AM
4. Additive Manufacturing: Our use of AM will serve two-purposes: first, we will use AM to validate the proposed design output from our bio-inspired optimization tool; second, we will ultimately use AM to manufacture bio-inspired parts, such as a heat exchangers or structural brackets that can be used in aerospace engineering.

Anticipated Benefits

Design and Manufacturing of high performance Materials for use in
- Heat Exchangers
- Lightweight structures
- Space debris resistant skins

Design and Manufacturing of high performance materials for use in
- Lightweight structures
- Heat Exchangers
- Protective Armor
- Acoustic Liners



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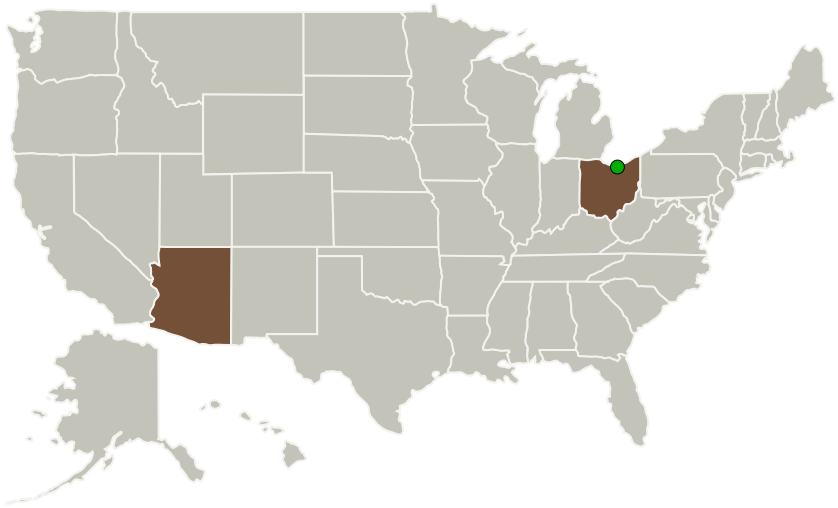
- Shock Absorption

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Phoenix Analysis and Design Technologies	Lead Organization	Industry	Tempe, Arizona
Arizona State University-Polytechnic	Supporting Organization	Academia	Mesa, Arizona
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
Arizona	Ohio

Project Transitions

July 2018: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Phoenix Analysis and Design Technologies

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Dhruv Bhate

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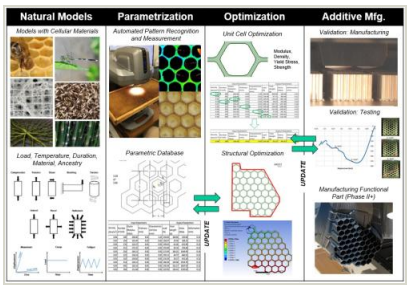
September 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141290)*

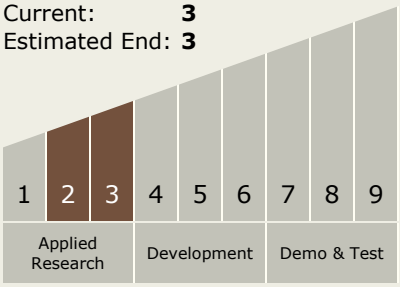
Images



Briefing Chart Image
Bio-inspired Cellular Material Optimization for the Design of Additively Manufactured Multi-Functional Lightweight Structures, Phase I
(https://techport.nasa.gov/image/127656)

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.2 Computational Materials

Target Destinations

Earth, Foundational Knowledge